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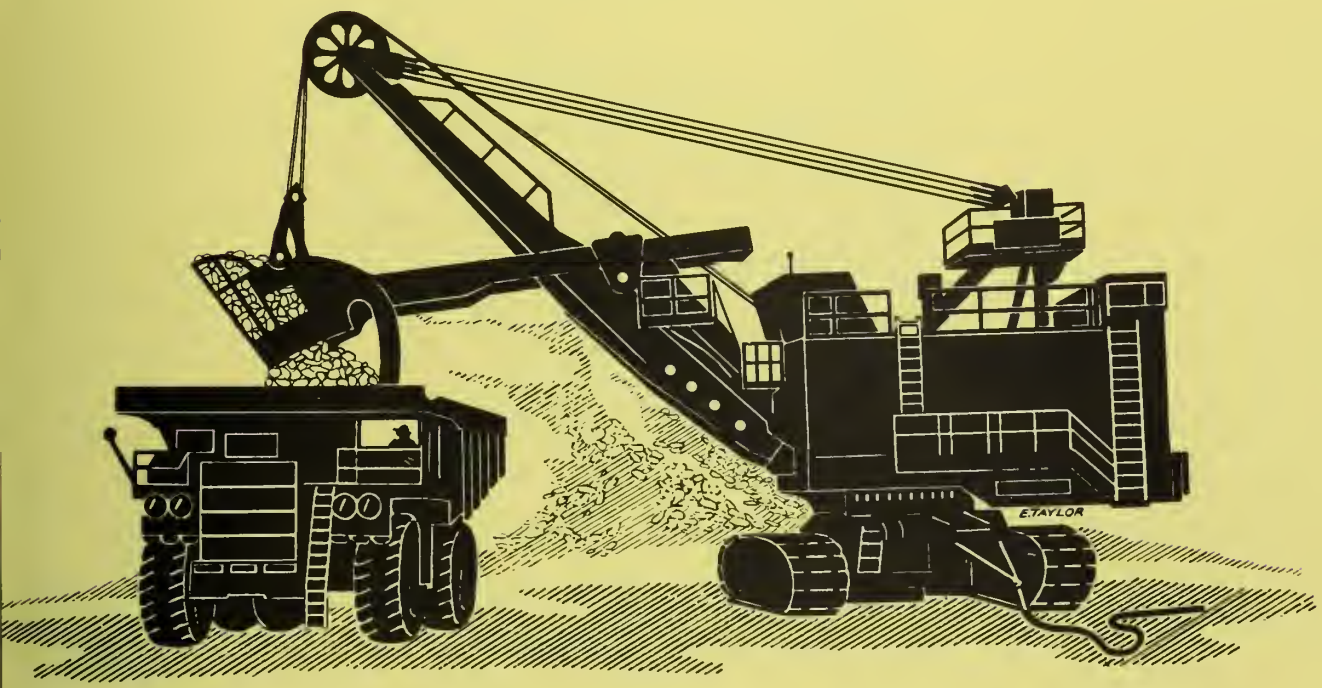
MINERAL COMMODITY REPORT

——SODIUM SULFATE——

1985



CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

SPECIAL PUBLICATION 81

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SPECIAL PUBLICATION 81

MINERAL COMMODITY REPORT

——SODIUM SULFATE——

1985

By
HASMUKHRAI H. MAJMUNDAR

Part I from
the U.S. Bureau of Mines publication,
Mineral Commodity Summaries, 1984

CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY
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INTRODUCTION

This report on the availability and demand for sodium sulfate (salt cake) in the United States, the world, and California, is one of a series of Mineral Commodity Reports prepared by the Department of Conservation's Division of Mines and Geology (DMG) to describe the mineral commodities of significant importance to California and the nation.

This report was compiled by Hasmukhrai H. Majmundar of the DMG geologic staff. Part I consists of United States and world-wide mineral-statistic information and analysis adopted directly from the U.S. Bureau of Mines "Mineral commodity Summaries" (1984). Part II discusses production of the commodity in California. The U.S. Bureau of Mines presents the earliest Government estimates of non-fuel mineral-industry data, including world resource data provided by the U.S. Geological Survey.

In 1983, the United States produced 470,000 and 430,000 short tons of natural and synthetic sodium sulfate, respectively, imported 450,000 short tons, and exported 90,000 short tons. The nation had an apparent consumption of 1.27 million short tons of both natural and synthetic salt cake. The total estimated value of domestically produced salt cake in 1983 was about $77 million. Due to increased demand in 1983, a shortage in sodium sulfate commodity was forecast. But increases in the production of synthetic sodium sulfate as a byproduct of rayon, sodium bichromate, lithium compounds and other chemicals, as well as the import of natural sodium sulfate from Mexico, Belgium, and the Federal Republic of Germany fulfilled the increased demand. Estimated domestic mine production of sodium sulfate for 1984 is in the range of 500,000 short tons; apparent U.S. consumption is 1.3 million short tons. The demand for sodium sulfate in the United States is expected to increase at an annual rate of about 1 percent through 1990.

Sodium sulfate is utilized largely in the manufacture of pulp and paper (48 percent). It is also used in the manufacture of detergents (39 percent) and glass. Miscellaneous uses include ceramics, metallurgy, and for cattle feed (13 percent). The largest use of sodium sulfate in California is in the manufacture of synthetic detergent and glass. The glass prepared by using sodium sulfate is very uniform in nature. When soda ash or calcium sulfate is substituted for sodium sulfate in glass making, the finished glass remains nonuniform. If price and availability are favorable, caustic soda and emulsified sulfur are substituted for sodium sulfate in the paper industry. In 1983, about 450 workers were directly employed nationwide in mines and plants.

In California, sodium sulfate is commercially produced only from the brines of Searles Lake by Kerr-McGee Chemical Corporation's two plants at Trona and Westend in Searles Lake, in San Bernardino County. California produces an average of about 80 percent of all the natural sodium sulfate produced in the United States. The estimated yearly production figure for California is about 300,000 short tons of sodium sulfate. The approximate reserve of sodium sulfate in Searles Lake is 500 million tons. At the present rate of consumption, world resources are sufficient to meet demands for hundreds of years.

For further information please call (916) 445-5716, the DMG centralized information number.

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PART I: UNITED STATES AND WORLDWIDE

1. UNITED STATES PRODUCTION AND USE

Sodium Sulfate: The domestic production of natural sodium sulfate increased in 1983 compared with that of 1982 because of increased domestic demand. About one-half of the U.S. sodium sulfate production was a byproduct from various chemical and rayon manufacturing plants. Total production of sodium sulfate was valued at about $77 million in 1983. Three producers of natural sodium sulfate operated four plants in California, Texas, and Utah. The major end uses of sodium sulfate were pulp and paper, 48%; detergents, 39%; and glass and miscellaneous, 13%.

2. SALIENT STATISTICS -- UNITED STATES

Sodium Sulfate (Data in thousand short tons unless noted):

	1979	1980	1981	1982	1983
Production:					
Natural	533	583	608	895[1]	470
Synthetic[2]	588	556	469	--	430
Imports for consumption:	188	230	275	394	450
Exports:	102	129	124	111	90
Apparent consumption: (natural and synthetic)	1,235	1,236	1,195	1,214	1,260
Price: Quoted, sodium sulfate--100% Na_2SO_4, bulk, f.o.b. works, East, dollars per ton	66.00	$78.00	$78.00	103.00	$103.00
Average sales value (natural source), f.o.b. mine or plant, dollars per ton	$55.79	$62.42	$71.03	$83.30	$85.00
Producer stocks at yearend, natural	29	33	66	30	20
Employment: wells and plants	500	500	500	450	450
Net import reliance[3] as a percent of apparent consumption	9	8	10	26	29

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e Estimated. NA = not available.

1 Includes synthetic sodium sulfate because natural sodium sulfate production data were withheld in 1982 to avoid revealing company proprietary data.

2 Source: U.S. Bureau of the Census.

3 Defined as imports - exports + adjustments for Government and industry stock changes.

Prepared by D.S. Kostick, telephone number (202) 634-1177.

3. RECYCLING

There was some recycling of sodium sulfate by consumers, particularly in the pulp and paper industry, but no recycling by sodium sulfate producers.

4. IMPORT SOURCES (1979-82)

Canada 96%, Belgium 1%, Mexico 1%, United Kingdom 1%, Other 1%.

5. TARIFF

Item	Number	Most Favored Nation (MFN)		Non-MFN
		1/1/84	1/1/87	1/1/84
Crude (salt cake)	421.42	Free	Free	Free
Anydrous	421.44	36¢/l.t.	33¢/l.t.	$3/l.t.
Crystallized (Glauber's Salt)	421.46	2.7% ad val.	2.5% ad val.	4% ad val.

6. DEPLETION ALLOWANCE

14% (Domestic), 14% (Foreign). For natural only.

7. GOVERNMENT STOCKPILE

None.

8. EVENTS, TRENDS, AND ISSUES

Domestic consumption of sodium sulfate increased in 1983 because of improved economic conditions that affected the pulp and paper and detergent industries. In 1982, a shortage of sodium sulfate available for domestic consumption was anticipated for 1983; however, increased imports from Mexico, Belgium, and the Federal Republic of Germany and an increase in byproduct sodium sulfate recovery from domestic chemical operations eliminated the potential supply problem. Byproduct recovery of sodium sulfate increased because of an increase in rayon, sodium bichromate, and lithium compound production.

At midyear, a hydrochloric acid plant with byproduct sodium sulfate capacity of 120,000 tons per year was closed at Weeks Island, Louisiana. In September, a new hydrochloric acid plant with byproduct sodium sulfate capacity of 90,000 tons per year came onstream near Grantsville, Utah. The plant used the Cannon fluidized process that requires salt and sulfuric acid as raw materials.

It is estimated that in 1984 domestic mine production of sodium sulfate will be 500,000 tons and U.S. apparent consumption will be 1,300,000 tons. From a 1979 base, demand for sodium sulfate is expected to increase at an annual rate of about 1% through 1990.

9. WORLD MINE PRODUCTION AND RESERVE BASE (Natural Sources)

	Mine Production		Reserve Base*
	1982	1983e	
United States	895[1]	470	940,000
Argentina	62	60	NA
Canada	605	610	92,000
Chile	1	2	NA
Iran	11	10	NA
Mexico	469	480	180,000
Spain	276	300	200,000
Turkey	88	90	NA
Other Market Economy Countries	7	7	NA
U.S.S.R.	397	400	2,000,000
World Total (may be rounded)	2,810[4]	2,400	NA

10. WORLD RESOURCES

Sodium sulfate resources are sufficient to last hundreds of years at the present rate of world consumption. In addition to the above countries, identified resources of sodium sulfate exist in Botswana, Egypt, Italy, Mongolia, Romania, and the Republic of South Africa.

11. SUBSTITUTES

Although caustic soda and emulsified sulfur have occasionally replaced sodium sulfate to deliquify wood for paper manufacture when the price and availability of the substitutes were favorable, there are no current plans to change permanently to this alternate process. In glassmaking, soda ash or calcium sulfate has been substituted for sodium sulfate, but the finished glass was nonuniform.

* Pending establishment of criteria for the reserve base, classification of data is based on a judgmental appraisal of current knowledge and assumptions.

[4] Includes synthetic sodium sulfate production from the United States.

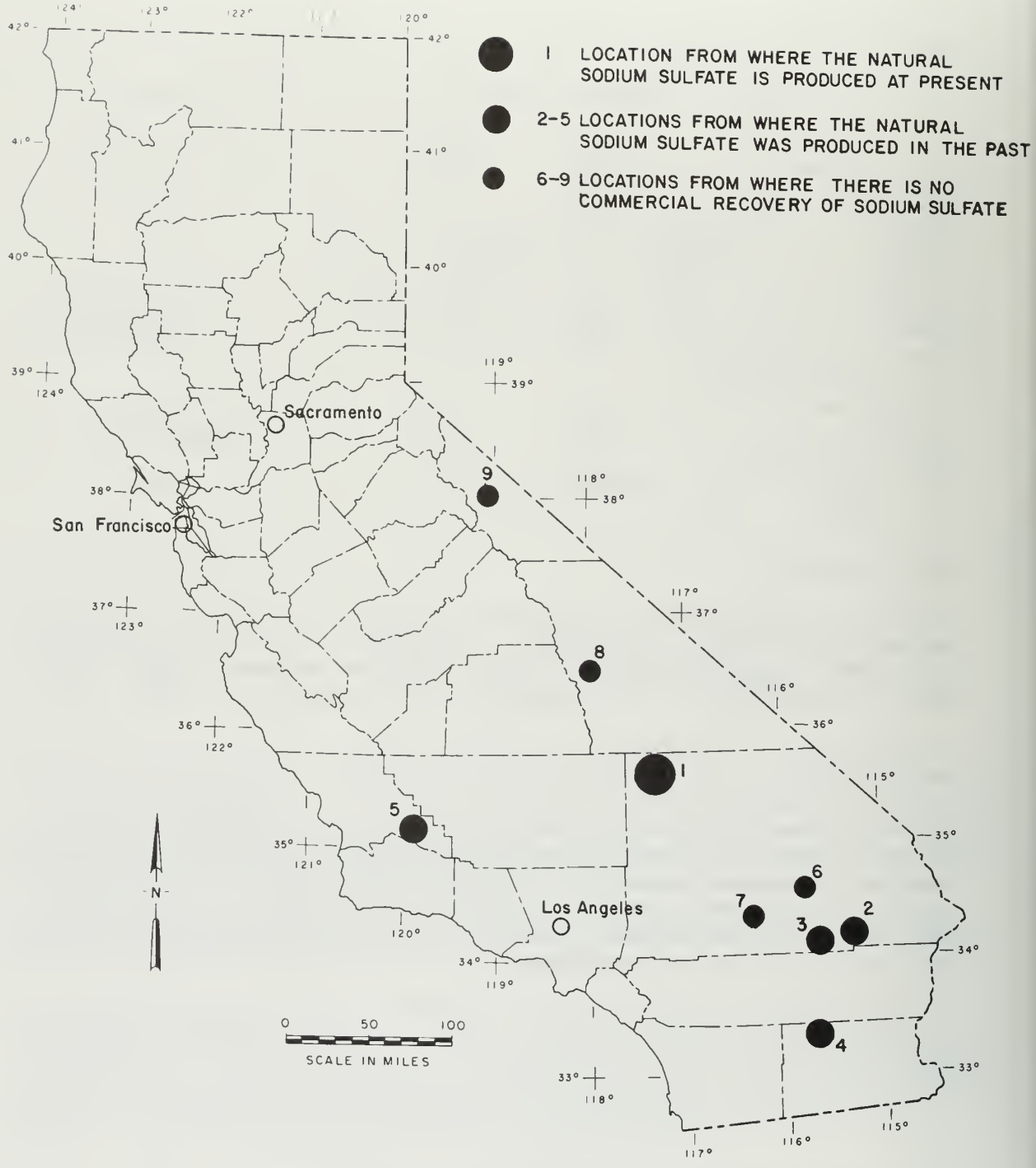
1 LOCATION FROM WHERE THE NATURAL SODIUM SULFATE IS PRODUCED AT PRESENT
2-5 LOCATIONS FROM WHERE THE NATURAL SODIUM SULFATE WAS PRODUCED IN THE PAST
6-9 LOCATIONS FROM WHERE THERE IS NO COMMERCIAL RECOVERY OF SODIUM SULFATE
Sacramento
San Francisco
Los Angeles
N
0 50 100
SCALE IN MILES

Figure 1. Sodium sulfate deposits in California.

PART II: CALIFORNIA

12. CALIFORNIA GEOLOGICAL OCCURRENCES

Sodium sulfate is known as salt cake in the commercial field. Both "natural" and "synthetic" salt cake are produced. Natural sodium sulfate occurs in solution in brines, as crystalline bodies in brines, as efflorescent crusts in playa lakes, and as beds in sedimentary rocks. Synthetic sodium sulfate is recovered as a byproduct of other chemical manufacturing processes. The common sodium sulfate minerals are the mirabilite ($Na_2SO_4.10\ H_2O$) and thenardite (Na_2SO_4). Mirabilite occurs as crusts or efflorescences that are white, soft, transparent-to-opaque needles with vitreous luster. It is much more soluble in warm water than in cold. When the mineral is exposed to dry air, it loses its water of crystallization and turns into fine powder. Thenardite is soluble in water. Its solubility decreases with increase in water temperature. This mineral is white to brownish with euhedral to anhedral crystal form. The name salt cake is also applied to the deposits of natural mineral thenardite. Other sodium sulfate minerals are glaserite ($Na_2SO_4.3K_2SO_4$), bloedite ($Na_2SO_4.MgSO_4.4H_2O$), glauberite ($Na_2SO_4.CaSO_4$), hanksite ($9Na_2SO_4.2Na_2CO_3Kcl$), and burkeite ($2Na_2SO_4.Na_2CO_3$).

13. CALIFORNIA LOCALITIES

In California, sodium sulfate is produced only from the brines of Searles Lake by Kerr-McGee Chemical Corporation's two plants at Trona and Westend, in Searles Lake, in San Bernardino County (Figure 1). The predecessor of Kerr-McGee Chemical Corporation, the American Potash and Chemical Corporation, used to recover sodium sulfate by spraying raw brine in a prepared area of the lake surface. This operation was done during winters. The brine was chilled sufficiently for the crystallization of mirabilite. This crude mirabilite was scraped up, brought to the plant, and refined.

There are other deposits at several localities in California that yielded sodium sulfate in the past. It was produced from the brines of Dale Lake, San Bernardino County. Dale Lake has lenticular beds of mixed thenardite and halite separated by impervious clay beds. Thenardite-halite beds are about 40 feet thick; the mixed series extends up to about 300 feet. These beds are permeated with sodium chloride (about 22 percent) and sodium sulfate (about 7 percent). It was the experience of the company, working in the past on these deposits, that it was difficult to produce a marketable product from the bedded material; production had been only from

Table 1. List of sodium sulfate deposits.

1. Trona and Westend, Searles Lake, San Bernardino County.
2. Danby Lake, San Bernardino County.
3. Dale Lake, San Bernardino County.
4. Durmid Hills, Imperial County.
5. Soda Lake, San Luis Obispo County.
6. Old Dad Mountains, San Bernardino County.
7. Emerson Dry Lake, San Bernardino County.
8. Owens Lake, Inyo County.
9. Mono Lake, Mono County.

the brine pumped from a well to a depth of at least 250 feet in the thenardite-halite beds. Dale Lake might have several million tons of sodium sulfate, but its production is restricted because of its distance from the nearest railroad loading station at Amboy.

Thenardite and bloedite also occur in the folded Tertiary shales and sandstones of Durmid Hills, Imperial County (Morton, 1977). The sulfates are exposed over an area of about 3,000 feet long and about 2,500 feet wide, ranging in thickness from 3 inches to 5 feet. These beds are high in magnesium sulfate (4 percent).

Another locality of sodium sulfate is at Soda Lake, San Luis Obispo County. Soda Lake occupies the undrained basin between the Caliente and Temblor Ranges. About an inch thick mirabilite covers an area of about 3,000 acres. Mirabilite has filled the channels around the lake, where it attains the thickness of up to 6 feet. Under this thin crust of mirabilite, there is a brine permeated mud with crystals of mirabilite and bloedite. Though the deposit is thin, it is estimated to contain over a million tons of mirabilite. Sodium sulfate was produced in the past from Soda Lake by dissolving the crust, collecting the brine, and recrystallizing sodium sulfate in ponds by solar evaporation.

Danby Lake in San Bernardino County has in the past produced a few carloads of sodium sulfate from small mushroom-shaped mirabilite crystals that are disseminated in the mud.

Additional sodium sulfate deposits have been found in Black Basin in Old Dad Mountains, at Emerson Lake, 60 miles east of Victorville and in the brines of Owens and Mono Lakes, but the mineral has not been recovered commercially from any of these deposits.

14. CALIFORNIA PRODUCTION

Production of sodium sulfate increased in 1983. Natural and synthetic sodium sulfate are produced in almost equal tonnages in the United States. The amounts of natural sodium sulfate and synthetic sodium sulfate produced in this country, and the amount of sodium sulfate imported had a 1:1:1 proportion. Of the natural sodium sulfate produced in the United States, California produced about 80-90 percent. Kerr-McGee Chemical Corporation is producing sodium sulfate from the brines of Searles Lake in California at only two plants (Trona and Westend). The production figures for these plants are confidential and hence can not be given here. The estimated figure for total yearly production in California is about 300,000 tons. Much of the supply of sodium sulfate is a byproduct of chemical processes used in the manufacture of hydrochloric acid from sulfuric acid and salt, the manufacture of rayon, and the manufacture of chromium chemicals, as well as other miscellaneous chemical processes including phenol sulfonation and the manufacture of formic acid, boron chemicals, and lithium chemicals. During recent years, the production of synthetic sodium sulfate has increased because of increases in the production of these above chemicals.

Demand for sodium sulfate exceeds its supply. Therefore, this commodity is imported--mostly from Western Canada and Mexico into California.

15. UTILIZATION AND MARKETS

The main uses of sodium sulfate are in the manufacture of pulp and paper (48 percent), detergents (39 percent), and glass and miscellaneous (13 percent). In the Kraft process (sulfate process) for making pulp, sodium sulfate is reduced with carbonaceous material and a solution of sodium sulfide, caustic soda, and sodium carbonate is produced. Wood chips are cooked in this alkaline liquor to dissolve the lignin and free the cellulose fibers. The next greatest use of sodium sulfate is in the manufacture of synthetic detergent and glass. This is the greatest use of salt cake in California. In detergents, sodium sulfate acts as a binder and bulking agent. The glass prepared by using sodium sultate is uniform in nature; when soda ash or calcium sulfate is substituted for sodium sulfate the finished glass remains nonuniform. Additional miscellaneous uses are in ceramics, metallurgy, and for cattle feeds.

Most of sodium sulfate is sold in the market in two forms, salt cake and anhydrous sodium sulfate. Natural thenardite deposits are also known as salt cake. Over and above anhydrous sodium sulfate, another commercial sodium sulfate compound is glauber salt, which is synthetic, the natural equivalent of which is mirabilite.

The Kerr-McGee Chemical Corporation's two facilities at Trona and Westend are the only plants producing sodium sulfate. There are a total of 1,000 employees working for Kerr-McGee Chemical Corporation in the Searles Valley, including those working at the recently established Argus plant.

16. MINING METHODS AND BENEFICIATION

Sodium sulfate is commonly produced from natural brines. It is also produced when treating brines to produce borax, potash, lithium, and soda ash. In this process, the brine is first treated in a series of three evaporators (Figure 2). Then it is passed through a salt removal system. From this step, concentrated liquor is sent to two different systems of treatment, one to produce potash and borax and the other to produce soda ash, lithium and salt cake. The clarified liquor from the lithium recovery is sent to the Glauber's salt crystallizer (sulfate process), where anhydrous sodium sulfate is precipitated.

Two deposits of natural thenardite from surface deposits at Dale Lake and Durmid Hills have been worked in the past by open-cut mining methods.

17. CALIFORNIA EVENTS, TRENDS, AND ISSUES

The consumption of salt cake is increasing year by year, and the present day production of sodium sulfate will not be sufficient to fulfil the demand of the industries utilizing sodium sulfate. Moreover, the general flow sheet for the production of various salines from the natural brines (Figure 2) also shows that if an industry increases the production of one commodity, that increase will be at the expense of the other commodities.

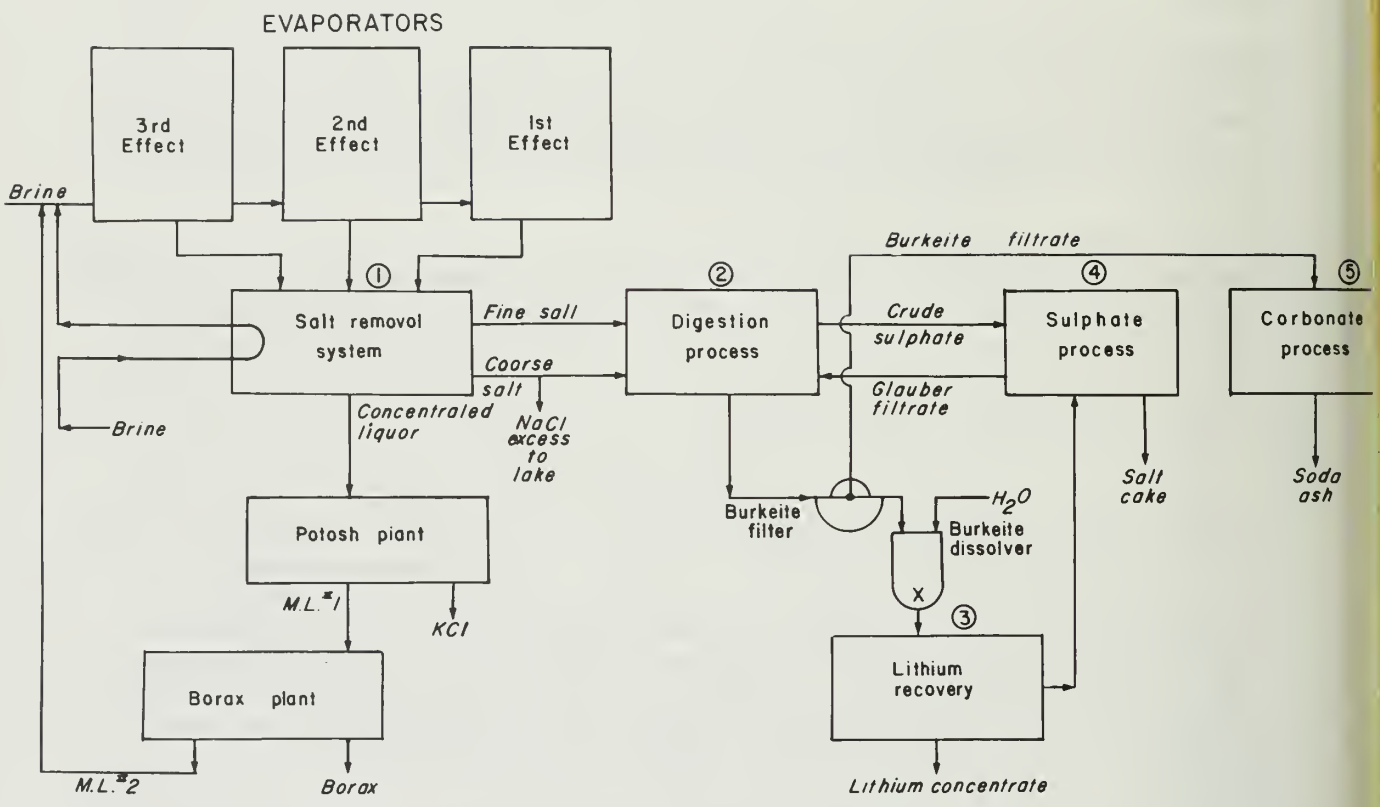

Figure 2. General flowsheet illustrating the process for recovering various salines from brines (after Hightower, 1951).

In other words, to increase the production of the salt cake, the production of soda ash or lithium or potash or borax has to be sacrificed. To meet their needs, industries have depended to some extent, therefore, on the imports of salt cake from western Canada or Mexico or other foreign countries.

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